In re Application of Carl L. Crandall et al.
Title: Offline Emulated Input/Output Processor Debugger
Attorney Docket RA 5570 (USYS.068PA) - Customer ID 27516
Attorney: Charles A. Johnson (Reg. 20,852) - (651) 635-7702
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Drawing 1 of 9

FIG. 1

(Prior art)

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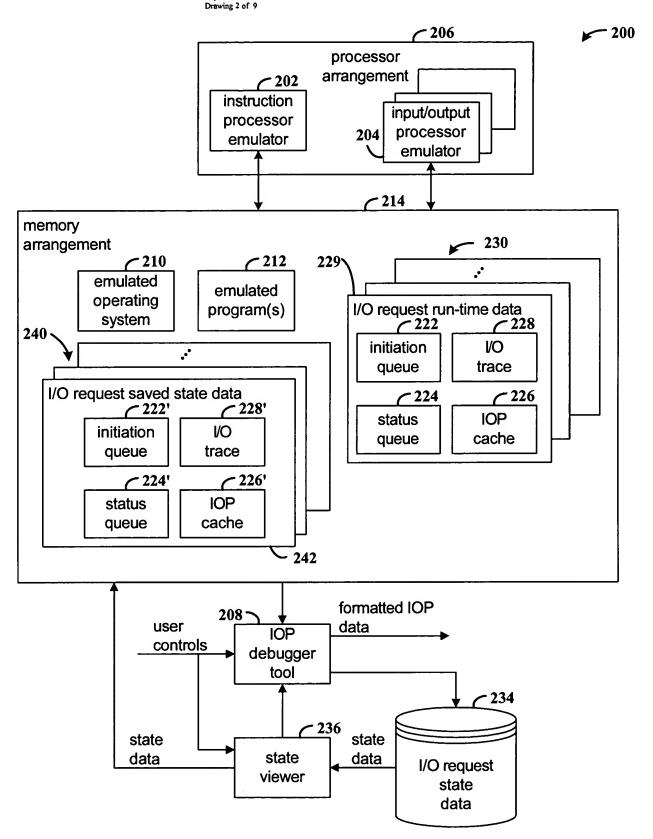Express Mail ER048647947US
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FIG. 2A

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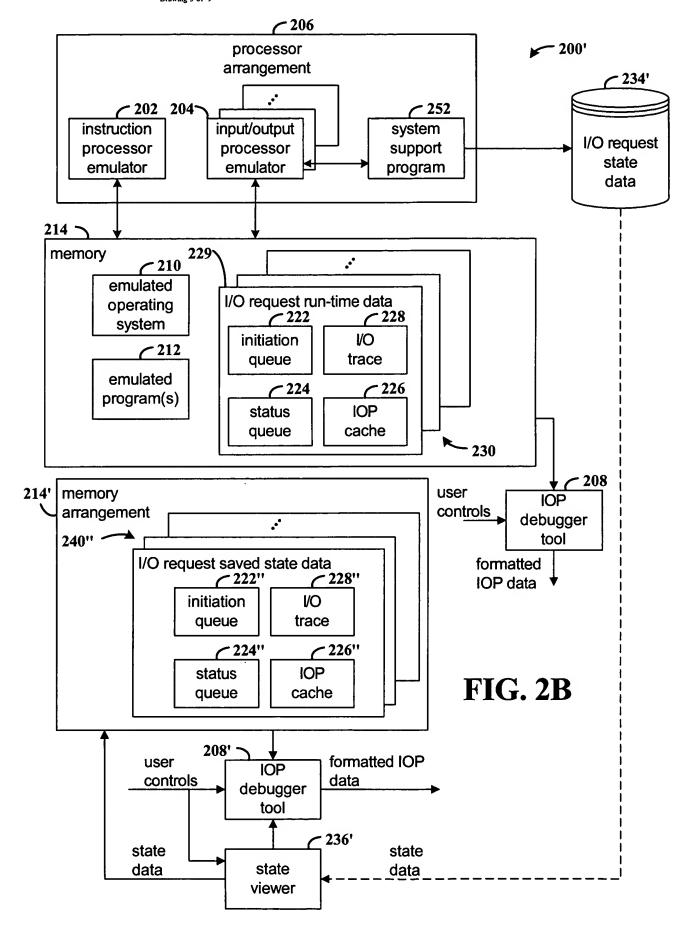Express Mail ER048647947US
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206

processor arrangement

200'

202
instruction processor emulator

204
input/output processor emulator

252
system support program

234'
I/O request state data

214

memory

210
emulated operating system

212
emulated program(s)

229
I/O request run-time data

222
initiation queue

228
I/O trace

224
status queue

226
IOP cache

230

214'
memory arrangement

240''

I/O request saved state data

222''
initiation queue

228''
I/O trace

224''
status queue

226''
IOP cache

208
user controls → **IOP debugger tool**

formatted IOP data ↓

208'
user controls → **IOP debugger tool** → formatted IOP data

state data →

236'
state viewer

state data

FIG. 2B

EMULATED OPERATING
SYSTEM PROCESSING
OF IO REQUESTS

302

Look up file location
information based on
request

304

Prepare a request packet
and queue the request
packet to the initiation
queue

306

Poll the status queue for
completed IO request

308

Return status to the
requester

310

Remove the status packet
from the status queue

Continue

FIG. 3

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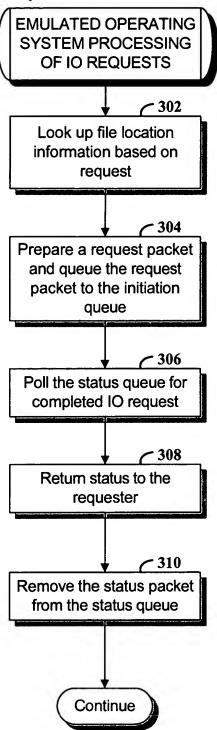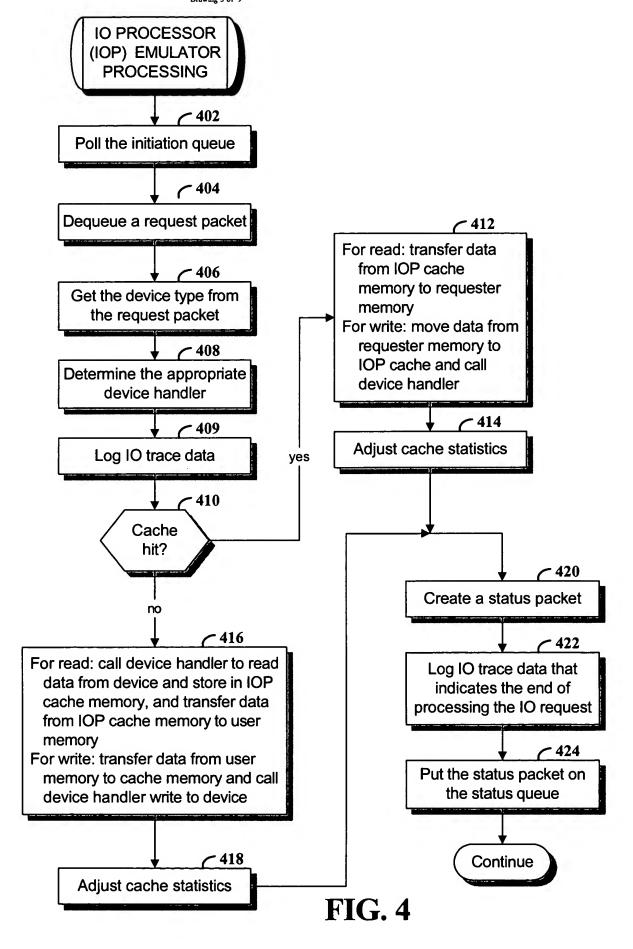Express Mail ER048647947US
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```
        ┌─────────────────────┐
        │   IO PROCESSOR      │
        │  (IOP)  EMULATOR    │
        │    PROCESSING       │
        └─────────────────────┘
                  │
                  ▼  ┌ 402
        ┌─────────────────────┐
        │ Poll the initiation queue │
        └─────────────────────┘
                  │
                  ▼  ┌ 404
        ┌─────────────────────┐
        │ Dequeue a request packet │
        └─────────────────────┘
                  │
                  ▼  ┌ 406
        ┌─────────────────────┐
        │ Get the device type from │
        │   the request packet     │
        └─────────────────────┘
                  │
                  ▼  ┌ 408
        ┌─────────────────────┐
        │ Determine the appropriate │
        │     device handler        │
        └─────────────────────┘
                  │
                  ▼  ┌ 409
        ┌─────────────────────┐
        │   Log IO trace data      │
        └─────────────────────┘
                  │
                  ▼  ┌ 410
              ╱ Cache ╲
             ⟨  hit?   ⟩
              ╲       ╱
```

┌ 412

For read: transfer data
  from IOP cache
  memory to requester
  memory
For write: move data from
  requester memory to
  IOP cache and call
  device handler

┌ 414

Adjust cache statistics

yes

no

┌ 416

For read: call device handler to read
data from device and store in IOP
cache memory, and transfer data
from IOP cache memory to user
memory
For write: transfer data from user
  memory to cache memory and call
  device handler write to device

┌ 418

Adjust cache statistics

┌ 420

Create a status packet

┌ 422

Log IO trace data that
indicates the end of
processing the IO request

┌ 424

Put the status packet on
the status queue

Continue

FIG. 4

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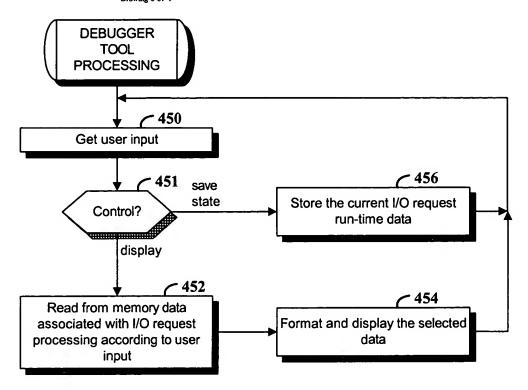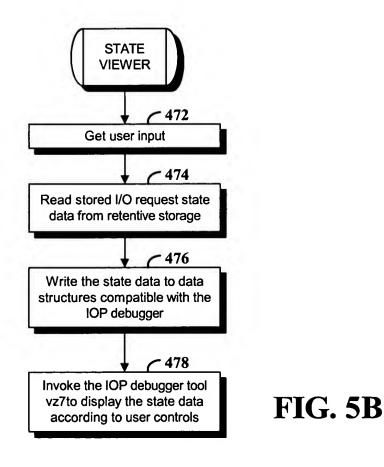Express Mail ER048647947US
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DEBUGGER
TOOL
PROCESSING

450
Get user input

451
Control?

save state

456
Store the current I/O request run-time data

display

452
Read from memory data associated with I/O request processing according to user input

454
Format and display the selected data

FIG. 5A

STATE
VIEWER

472
Get user input

474
Read stored I/O request state data from retentive storage

476
Write the state data to data structures compatible with the IOP debugger

478
Invoke the IOP debugger tool vz7to display the state data according to user controls

FIG. 5B

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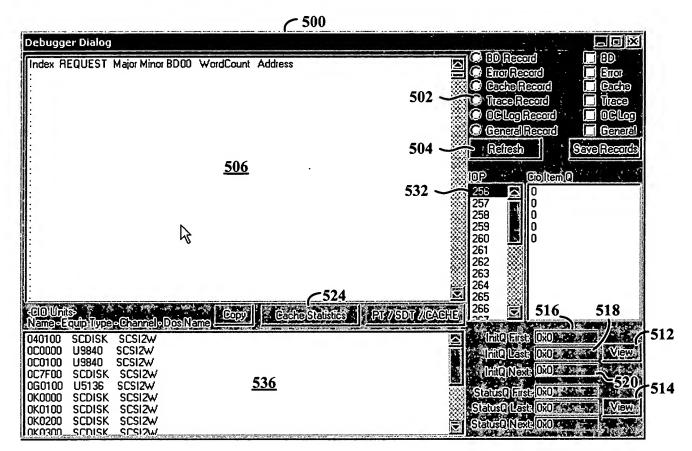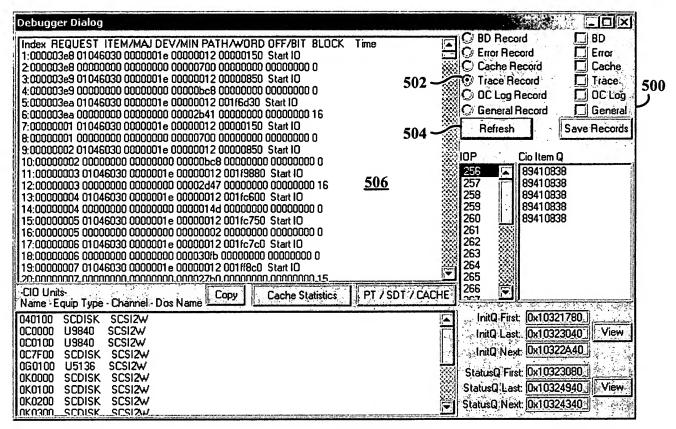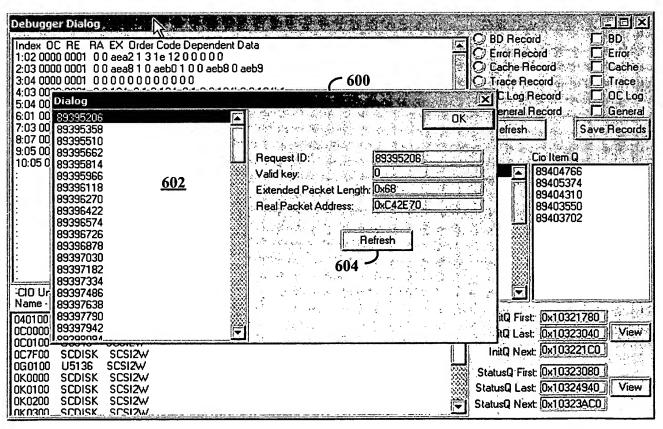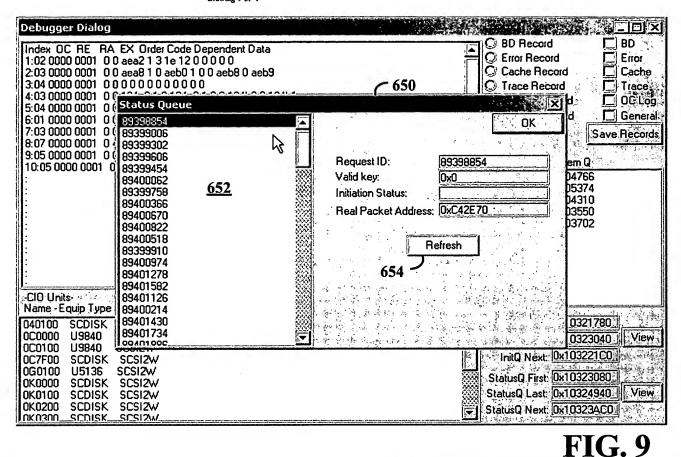Express Mail ER048647947US
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FIG. 6

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Debugger Dialog

```
Index REQUEST ITEM/MAJ DEV/MIN PATH/WORD OFF/BIT BLOCK  Time
1:000003e8 01046030 0000001e 00000012 00000150  Start IO
2:000003e8 00000000 00000000 00000700 00000000 00000000 0
3:000003e9 01046030 0000001e 00000012 00000850  Start IO
4:000003e9 00000000 00000000 00000bc8 00000000 00000000 0
5:000003ea 01046030 0000001e 00000012 001f6d30  Start IO
6:000003ea 00000000 00000000 00002b41 00000000 00000000 16
7:00000001 01046030 0000001e 00000012 00000150  Start IO
8:00000001 00000000 00000000 00000700 00000000 00000000 0
9:00000002 01046030 0000001e 00000012 00000850  Start IO
10:00000002 00000000 00000000 00000bc8 00000000 00000000 0
11:00000003 01046030 0000001e 00000012 001f9880  Start IO
12:00000003 00000000 00000000 00002d47 00000000 00000000 16
13:00000004 01046030 0000001e 00000012 001fc600  Start IO
14:00000004 00000000 00000000 0000014d 00000000 00000000 0
15:00000005 01046030 0000001e 00000012 001fc750  Start IO
16:00000005 00000000 00000000 00000002 00000000 00000000 0
17:00000006 01046030 0000001e 00000012 001fc7c0  Start IO
18:00000006 00000000 00000000 000030fb 00000000 00000000 0
19:00000007 01046030 0000001e 00000012 001ff8c0  Start IO
20:00000007 00000000 00000000 00002760 00000000 00000000 15
```

506

○ BD Record   ☐ BD
○ Error Record ☐ Error
○ Cache Record ☐ Cache
◉ Trace Record ☐ Trace
○ OC Log Record ☐ OC Log
○ General Record ☐ General

[Refresh]   [Save Records]

502
504
500

IOP   Cio Item Q
256   89410838
257   89410838
258   89410838
259   89410838
260   89410838
261
262
263
264
265
266

-CIO Units-
Name - Equip Type - Channel - Dos Name   [Copy] [Cache Statistics] [PT / SDT / CACHE]

```
040100  SCDISK  SCSI2W
0C0000  U9840   SCSI2W
0C0100  U9840   SCSI2W
0C7F00  SCDISK  SCSI2W
0G0100  U5136   SCSI2W
0K0000  SCDISK  SCSI2W
0K0100  SCDISK  SCSI2W
0K0200  SCDISK  SCSI2W
0K0300  SCDISK  SCSI2W
```

InitQ First: [0x10321780]
InitQ Last: [0x10323040]   [View]
InitQ Next: [0x10322A40]

StatusQ First: [0x10323080]
StatusQ Last: [0x10324940] [View]
StatusQ Next: [0x10324340]

FIG. 7

Debugger Dialog

```
Index OC RE  RA EX Order Code Dependent Data
1:02 0000 0001 0 0 aea2 1 3 1e 12 0 0 0 0 0
2:03 0000 0001 0 0 aea8 1 0 aeb0 1 0 0 aeb8 0 aeb9
3:04 0000 0001 0 0 0 0 0 0 0 0 0 0 0
4:03 00
5:04 00
6:01 00
7:03 00
8:07 00
9:05 00
10:05 0
```

○ BD Record   ☐ BD
○ Error Record ☐ Error
○ Cache Record ☐ Cache
○ Trace Record ☐ Trace
○ OC Log Record ☐ OC Log
○ General Record ☐ General

[Refresh]   [Save Records]

600

Dialog   [X]

```
89395206
89395358
89395510
89395662
89395814
89395966
89396118
89396270
89396422
89396574
89396726
89396878
89397030
89397182
89397334
89397486
89397638
89397790
89397942
89398094
```

602

[OK]

Request ID: [89395206]
Valid key: [0]
Extended Packet Length: [0x68]
Real Packet Address: [0xC42E70]

[Refresh]

604

Cio Item Q
89404766
89405374
89404310
89403550
89403702

-CIO Ur
Name -

```
040100
0C0000
0C0100
0C7F00  SCDISK  SCSI2W
0G0100  U5136   SCSI2W
0K0000  SCDISK  SCSI2W
0K0100  SCDISK  SCSI2W
0K0200  SCDISK  SCSI2W
0K0300  SCDISK  SCSI2W
```

InitQ First: [0x10321780]
InitQ Last: [0x10323040]   [View]
InitQ Next: [0x103221C0]

StatusQ First: [0x10323080]
StatusQ Last: [0x10324940] [View]
StatusQ Next: [0x10323AC0]

FIG. 8

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FIG. 9

FIG. 10